

Wednesday 19th September

Sidlaw • 08.00-18.10

EARLY RISER SESSION

Chair: Anil Gholkar

Lecture 10

08.00 - 08.15

AVMs and Pregnancy

Christian Stapf

*Hôpital Lariboisière & Univ Paris Diderot – Sorbonne
Paris Cité, Paris, France*

Brain AVMs have been repeatedly diagnosed in women during pregnancy, but the risk of spontaneous rupture during the pre- and perinatal period has not been systematically studied.

Prior cohort studies and population-based surveys showed no differences in demographic or clinical patient characteristics between women and men, and the spontaneous haemorrhage risk does not vary by gender during the physiological age of fertility. Literature data available at the time of this Early Riser seminar do not suggest an increased risk of haemorrhage during pregnancy or delivery.

Lecture 11

08.15 - 08.30

AVM and Epilepsy

Rustam Al-Shahi Salman

Western General Hospital, Edinburgh, UK

The most consistently reported associations with the occurrence of epileptic seizures for AVM are younger age, temporal location, cortical involvement, and nidus diameter greater than 3 cm. In the absence of prior intracranial haemorrhage and non-haemorrhagic focal neurological deficit, a population-based study in Scotland found that the five-year risks of first

seizure were 8% for arteriovenous malformations (AVM), although presentation with intracranial haemorrhage or focal neurological deficit raised this risk to 23%. In the absence of prior intracranial haemorrhage and non-haemorrhagic focal neurological deficit, the five-year risk of developing epilepsy following a first seizure is 58% for AVM, and the chance of achieving two-year seizure freedom in this time frame is 45%. Observational case series describe encouraging differences in seizure frequency before and after AVM treatment, but our population-based observational study in Scotland has not found a difference between AVM treatment and conservative management on the clinical course of epileptic seizures (although we cannot rule out the influence of confounding in a non-randomised study: adults undergoing AVM treatment tended to have higher frequencies of seizures prior to presentation, symptomatic seizures at ICH onset, temporal lobe AVM location, and these adults may have had a higher prospective risk of seizures). The shortage of studies demonstrating dramatic effects in comparison to concurrent control groups justifies the need for more controlled studies, ideally with randomised treatment allocation when the benefits of AVM treatment are uncertain.

Lecture 12

08.30 - 08.45

AVM and Cognitive Decline / RICP

JP Mohr

The NY Neurological Institute, New York, USA

Cognitive decline has a literature in dural fistulas, but rarely described for bAVMs. The attractive notion of 'cerebral steal' as the cause

gained credence from early angiographic studies showing the flood of contrast into the fistula when compared with the smaller, less well opacified adjacent vessels. But a basis intervention in bAVMs, 'steal' was not supported by the small literature (<20 PubMed references) of studies of rCBF and cerebral oxygenation near and in the bAVM zone. Further, the few (4% of 705, 7% of 735) bAVMs are reported with focal neurological deficits unrelated to seizures or hemorrhage are mostly of brainstem location and related distortion effect from large draining veins.

Seeking an explanation for bAVM syndromes and predictable response to intervention by modern imaging, DTI shows some bAVMs looking like subdurals, deviating or deforming what should be intact pathways through mass effect, as if the bAVM is a separate entity from local brain tissue. Others show infiltration and apparent tract interruption. Although for some modified WADA and fMRI studies show language is located contralaterally or at a distance from the bAVM, many show the expected normal localizations. Where studied, up to 66% acknowledged remote history of a learning disability during school-age years. These latter observations suggest bAVM brain organization may be affected from an early embryologic period.

Still unexplained is whether brain organization for higher cortical function is mediated mainly through longitudinal intra-hemispheric and trans-callosal pathways or more vertically oriented via the thalamus. The anatomic locations unusual for those from infarct and primary hematomas and the typical schizencephalic cleft associated with bAVMs before and after eradication offer unique opportunities for study. These in addition to the practical issue of natural history versus intervention in the ARUBA trial.

Lecture 13

08.45 - 09.00

Brain AVM and Aneurysms: Clinical Symptoms and Implications for Treatment

Karel G. terBrugge

University Health Network, University of Toronto

The clinical variability in the presentation of patients with brain arteriovenous malforma-

tions (B-AVM) may in part be due to the difference in host response to the presence of an AVM as demonstrated in the angioarchitecture.

Prenidal: Prenidal arterial abnormalities such as arterial ectasias and stenosis almost certainly represent an individual host response to the increased flow associated with the downstream fistula. Aneurysms involving the arterial circulation on the way to the AVM occur relatively frequently (15 to 25%) and in different locations (beyond the circle of Willis), as compared to patients without AVMs. These aneurysms proximal to an AVM may rupture and be responsible for clinical presentation. Current experience suggests that in the natural history the risk of hemorrhage is twice as high (7 versus 3.5%) in patients with brain AVM and arterial aneurysms versus those without arterial aneurysms. The Toronto experience has also shown that regression of aneurysms on the feeding vessels to the AVM may occur following complete obliteration of the AVM, but his effect is to be anticipated only on feeding vessel aneurysms, which are at a close distance from the AVM.

The presence of direct versus indirect feeders towards the AVM is of major importance with regard to the feasibility of endovascular treatment. Indirect feeders often occur in AVM locations near the watershed zone of major arterial territories. They can make angiographic assessment of the size and extent of the AVM difficult and for that purpose MRI examinations are not only helpful but also mandatory. It appears unlikely that indirect feeder supply to the AVM is associated with different or increased incidence of neurological symptoms caused by so called "steal phenomena", and this angiographic feature is mostly important from an endovascular versus surgical management point of view.

Nidus: Nidus angioarchitecture has previously been analyzed mostly with regard to neurosurgical parameters emphasizing size, location, venous drainage, etc. Superselective angiography has demonstrated intranidal aneurysms, pseudoaneurysms, venous ectasias and fistulous communications. The significance of these intranidal abnormalities has become more apparent over the last five years. The presence of intranidal aneurysms is most likely responsible for the two-fold risk of hemorrhage (7%) of patients with AVM and associated aneurysms. These aneurysms should be considered for endovascular treatment (targeted, partial) in particular in

those patients where for various reasons a complete cure of the entire AVM cannot be achieved, or a cure is anticipated to take several years (following stereotactic radiosurgery).

Remote: BAVMs that have associated aneurysms that are not on the feedings vessels leading towards the AVM or located inside the nidus are called remote aneurysms and most likely they carry the same risks for future hemorrhage as they do in the general population of symptomatic unruptured aneurysms not associated with BAVMs.

References:

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- 2 Redekop G, TerBrugge K, Montanera W, et al. Arterial aneurysms associated with cerebral arteriovenous malformations: classification, incidence, and risk of hemorrhage. *J Neurosurg.* 1998; 89 (4): 539-46.
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AVM CONTROVERSIES IN MANAGEMENT 2

Chair: Robert Spetzler

Panel: Robert Spetzler, Christer Lindquist, JP Mohr, Michael Söderman

Lecture 14

09.00 - 09.30

Trans Venous Approaches to AVMs Safety and Technical Issues

J. Moret¹, A. Zakaria², L. Spelle¹, L. Ikka¹

¹ Beaujon University Hospital 92110 Clichy (Paris), France; ² Interventional Neuroradiology at Cairo University, Cairo, Egypt

Introduction: Trans-venous approach has been described for endovascular treatment of many vascular lesions namely the intracranial dural, cavernous and intra-orbital malformations. This paper analyses some indications for this new approach for retrograde embolization of cerebral AVMs and describes the technique that makes it safe and effective based on the arterial obliteration experience.

Patients And Methods: 12 patients with small cerebral AVMs (nidus less than 2 cm in size) were embolized with Onyx 18 through venous approach. 7 cases presented with the bleeding (no previous treatment), 3 cases previously received one or two sessions of trans-arterial embolization using Onyx 18, 1 case post-surgical and 1 case post radio-surgical treatment.

Results: Successful obliteration of all attempted cases with one incidence of small parenchymal bleeding. The patient recovery was uneventful with no deficits. No evidence of recurrence on the 1 year follow up done in 7 patients and the rest are scheduled.

Conclusion: The technique of trans-venous approach for retrograde embolization of cerebral AVMs in properly selected cases offers a promising alternative in achieving complete endovascular cure of these lesions.

Lecture 15

09.30 - 09.45

Normal Perfusion Pressure Break Through and Cerebral Hyperperfusion; Fact or Convenient Myth

Richard J Nelson

Frenchay Hospital, Bristol, UK

A telephone call at 5:00 am, 10 hours after completing the excision of a 3cm left pre-frontal AVM, wakens you with the unwelcome news that your patient has suddenly deteriorated with a right hemiparesis. Despite exemplary post-operative blood pressure control on ICU, the CT scan shows a large, deep seated haematoma. The CT angiogram shows nothing. Later that morning the post-evacuation angiogram is equally unimpressive. Just another case of normal perfusion pressure breakthrough, cerebral hyperperfusion and haemorrhage? Nearly 35 years after the pathophysiology of NPPB was first de-

scribed: is its existence supported by contemporary studies; how common is it; can we predict it; how should we manage and prevent it; is it really the cause of post-operative haemorrhage and cerebral swelling or just a convenient scapegoat for poor planning or inadequate surgery?

Lecture 16

09.45 - 10.10

AVM Risk Management – How to Avoid and How to Manage Complications

Andras Kemeny

Royal Hallamshire Hospital, Sheffield, UK

It is a fact that it is much easier to learn how to avoid complications at radiosurgery than at microsurgery. Patient selection is paramount for good statistics but does not help the individual complicated case. Having said that, using endovascular treatment for nidus aneurysms reduces the risk of bleed during the latency period. At radiosurgery, the principles of good radiosurgery are to be followed. Any treatment can be only as precise as the imaging: high quality angiography must be combined with MRI of similar quality. CTA is useful in selected, unembolised, cases. Treatment plan must avoid overtreatment of normal parenchyma – experience of the planner is the key. Complications include vasogenic oedema around 6-9 months, treated with dexamethasone; the use of Avastin and hyperbaric oxygen are under investigation. Late complications include radionecrosis that may require excision of an enlarging mass even after many years; thankfully, after complete obliteration of the nidus this becomes a straightforward procedure. Liquefaction necrosis (cyst formation) is easily treated with marsupialisation. Increasing evidence is available showing that any risk of malignancy after radiosurgery even for these benign pathologies, if at all exists, is negligible.

Lecture 17

10.10 - 10.35

Targeted Embolisation for Brain AVMs

Georges Rodesch

Hôpital Foch, Suresnes, France

Targeted embolization of a brain AVM (BAVMs) is an endovascular treatment fo-

cused on architectural points that are at risk for hemorrhages, or on zones of the AVM responsible for neurological symptoms. The concept of angioclinal semiology is therefore important when one considers treatment of BAVMs. Accurate assessment of these findings is important as misinterpretations may lead to embolization of the wrong part of the AVM, destabilising it further, making the patient more symptomatic and increasing the risk of hemorrhage.

The aim of such a treatment is to be protective, either as first step in a more global management of AVMs, or as palliative treatment in non curable lesions. The rationale for partial embolization is derived from the concept that the patient (the host) will be asymptomatic as long as there is an equilibrium between host and AVM. Treatment should be carried out once the patient becomes symptomatic to re-establish this equilibrium. To accomplish this goal, curative treatment may not be necessary and partial targeted embolization may be sufficient. Palliative embolizations concern patients with progressive neurological symptoms due to AVMs that cannot be cured by current technology or because of their locations in deep, dangerous or highly eloquent areas of the brain. Veins are usually responsible for these progressive deficits, and the reduction of their congestion and of the hyperpressure reigning into them tends to stabilize or reverse the neurological deficits. Partial targeted embolization, when carried out with complete understanding of the clinical -angioarchitectural relationships, improves the natural history of BAVMs.

Lecture 18

10.35 - 11.00

Surgery: Understanding Complex Dural Fistulas

Michael T. Lawton

University of California, San Francisco, USA

Objective: Tentorial dural arteriovenous fistulae (DAVF) are rare, have a high risk of hemorrhage, often cannot be obliterated endovascularly, and frequently require microsurgical interruption of the draining vein. We differentiated these fistulae into 6 types and developed specific operative strategies based on these types.

Methods: During a 9-year period, 31 patients underwent microsurgical treatment for tentori-

al fistulae: 7 Galenic DAVFs, 8 straight sinus DAVFs, 3 torcular DAVFs, 3 tentorial sinus DAVFs, 8 superior petrosal sinus DAVFs, and 2 incisural DAVFs.

Results: The posterior interhemispheric approach was used with Galenic DAVFs; the supracerebellar-infratentorial approach was used with straight sinus DAVFs; a torcular craniotomy was used with torcular DAVFs; the supratentorial-infraoccipital approach was used with tentorial sinus DAVFs; the extended retrosigmoid approach was used with superior petrosal sinus DAVFs; and a pterional or subtemporal approach was used with incisural DAVFs. Angiographically, 94% of fistulae were obliterated completely. Four patients had transient neurological morbidity; none had permanent neurological morbidity; and there was no operative mortality (mean follow-up, 4.2 years).

Conclusion: Tentorial DAVFs can be differentiated based on fistula location, dural base, associated sinus, and direction of venous drainage. The operative strategy for each type is almost algorithmic, with each type having an optimum surgical approach and an optimum patient position that allows gravity to retract the brain, open subarachnoid planes, and shorten dissection times. No matter the type, the fistula is treated microsurgically by simple interruption of the draining vein.

SPINAL VASCULAR LESIONS

Chair: Gary Steinberg

Lecture 19

11.30 - 12.00

Spinal Vascular Anatomy and its Implications for Treating Spinal Vascular Malformations

Georges Rodesch

Hôpital Foch, Suresnes, France

Intradural spinal cord AVMs are considered to be dangerous lesions not only because of the eloquence of the nervous tissue that is involved, but also because of the anatomy of the cord vasculature that is considered difficult.

This anatomy cannot be summarized to a gross external morphological description of anterior or posterior spinal axes: one must have in mind the microvascular disposition of the in-

trinsic arterial and venous vessels of the cord when one analyzes a spinal cord AVM. Indeed, these shunts, specially when embedded into the cord, have intimate relationships with the normal cord vasculature and one needs, in order to avoid damage to the normal cord tissue, to recognize the pathological vessels from the normal ones that react to the shunt and are often intermingled within it.

These vessels are furthermore also submitted to angiogenic activity in response to the AVM itself but may not be pathological per se. All these data (anatomy, physiology, biology) have to be recognized in order to propose satisfactory treatments to the patients affected by these lesions.

Optimal treatment may thus not be based exclusively on eradication of an abnormal angiographic picture, but on understanding of the disease, as the decision to embolize such shunts is based on anatomy of the vessels, architecture of the lesion, and symptoms presented by the patient. Properly performed, embolization targeted on the active parts of the lesion improves the natural history of these diseases at long term follow up.

Lecture 20

12.00 - 12.30

Radical Ablation of Spinal Cord AVM

John Adler

Stanford University, Stanford, USA

Objective: Intramedullary spinal cord arteriovenous malformations (AVMs) are very rare lesions which are characteristically associated with recurrent hemorrhage and progressive ischemia. Although favorable location, size and vascular anatomy make it sometimes possible to manage this condition with embolization and/or microsurgical resection, there are no good treatment options for many, if not most, of these lesions. Given such poor prospects, the senior author began in 1997 investigating CyberKnife radiosurgical ablation as a tool for managing selected patients with intramedullary spinal cord AVMs. Although a previous paper in 2006 reported the preliminary experience from Stanford, our understanding has grown significantly as follow-up was extended and more patients were treated. Herein, we retrospectively analyze our longer term experience

with a primary radiosurgical approach to spinal cord AVM.

Methods: Thirty patients (17 females: 13 males) with a median age of 33 years and intramedullary spinal cord AVMs (18 cervical, 9 thoracic, and three conus medullaris) were treated with CyberKnife SRS between 1997 and 2008. A history of hemorrhage was present in 57% of cases, while in 50% of patients previous treatment included microsurgery (6/29) or embolization (11/29). The mean AVM volume was 2.8 cc (0.2-15cc) was treated to mean marginal dose of 20Gy in one to four sessions (median 2). Based on our growing experience, the biologically effective dose (BED) of radiation was escalated gradually over the course of this study. Clinical and magnetic resonance imaging follow-up were carried out annually, and spinal angiography was repeated at 3 years.

Results: After a mean follow-up period of 63 months (median 54), the treated AVM was completely obliterated in 8 cases (27%) and significantly decreased in size in an additional 11 cases (64%) among the 22 angiographically studied patients with more than 3 years of follow-up. Pre-radiosurgery neurologic symptoms improved in more than 50% of cases, but worsened in three (10%). There was one instance (3%) of radiation-induced myelopathy occurring within one year of radiosurgery. Notably, after 158 years of collective post SRS follow-up, no patient suffered a hemorrhage.

Conclusion: Although our understanding is still incomplete, CyberKnife radiosurgery Results in total obliteration or shrinkage for most intramedullary spinal cord AVM, a phenomenon that may be accompanied by a marked decrease in the risk of bleeding. Symptom improvement is also common in most cases. More experience is required to determine the optimal radiosurgical dosing and consequent related efficacy. Given the significant therapeutic challenges inherent to spinal cord AVM patients, the rate of radiosurgical complications appears acceptable.

Lecture 21

12.30 - 13.00

Challenges for the Surgeon Presented by Spinal Vascular Lesions

Robert Spetzler

Barrow Neurological Institute, Phoenix, USA

Introduction: The literature on spinal vascular malformations contains a great deal of confusing terminology. Some of the nomenclature is inconsistent with the lesions described.

Methods: Based on the senior author's (R Spetzler) experience with more than 130 spinal cord vascular lesions and a thorough review of the relevant literature, we propose a modified classification system for spinal cord vascular lesions.

Results: Lesions are divided into three primary or broad categories: neoplasms, aneurysms, and arteriovenous lesions. Neoplastic vascular lesions include hemangioblastomas and cavernous malformations, both of which occur sporadically and familially. The second category consists of spinal aneurysms, which are rare. The final category, spinal cord arteriovenous lesions, is divided into arteriovenous fistulas (AVFs) and arteriovenous malformations (AVMs). AVFs are subdivided into extradural and intradural fistulas, with intradural lesions categorized as either dorsal or ventral. AVMs are subdivided into extra-intradural and intradural malformations. Intradural lesions are further divided into intramedullary, intramedullary-extramedullary, and conus, a new category of AVM.

Conclusions: This modified classification system for spinal cord vascular lesions, based on pathophysiology, neuroimaging information, surgical observations, and neuroanatomy, offers several advantages. First, it includes all surgical vascular lesions that affect the spinal cord. Second, it guides treatment by classifying lesions based on location and pathophysiology. Finally, it eliminates the confusion produced by the multitude of unrelated nomenclature found in the literature

LUNCHTIME PARALLEL SESSION 1

Carrick 2

Lecture 22

13.10 - 13.55

INR; How I Manage a Patient with a Cerebral AVM

Anton Valavanis

University Hospital Zurich, Zurich, Switzerland

Abstract not available at time of publication.

LUNCHTIME PARALLEL SESSION 2**Carrick 1****Lecture 23**

13.10 - 13.55

SRS; Indications and Risks of Retreatment of an AVMChrister Lindquist

BUPA Cromwell Hospital, London, UK

Abstract not available at time of publication.

LUNCHTIME PARALLEL SESSION 3**Ochil Suite**

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We make it visible.

Lecture 24

13.10 - 13.55

Perioperative and Preoperative Adjuncts to NeurosurgeryRobert Spetzler

Barrow Neurological Institute, Phoenix, USA

Arteriovenous malformations (AVMs) present a unique challenge and require a multidisciplinary approach for optimal management. In many cases, microsurgical resection remains the gold-standard for treatment of AVMs, but endovascular embolization and stereotactic radiosurgery have become important adjuncts in the treatment of some of the more challenging AVMs. The preoperative management of AVMs begins with aggressive and safe embolization of arterial feeders to the AVM. The natural history of AVMs and the morbidity profile of embolization must be weighed and decision to treat should be based on these factors. Current data suggests that embolization of Spetzler-Martin grade I and II AVMs harbors a morbidity profile that exceeds that of microsurgical resection. In this scenario, the combined risk of embolization and surgery outweigh the risk of surgery alone and embolization should be deferred. Endovascular embolization for grade III and select grade IV AVMs can be performed with acceptable morbidity. Post-embolization, the importance of tight blood pressure control cannot

be over-emphasized. A dedicated neurointensive care team with knowledge of the physiology of AVMs is critical to minimizing devastating complications. In the most challenging cases, AVMs cannot be adequately addressed by endovascular techniques or surgery and require the addition of radiosurgery to obliterate and minimize risk of hemorrhage. With improvements in radiosurgical tools and methods, stereotactic radiosurgery has grown in importance as an adjunct to surgery, endovascular technique and as a stand-alone in the treatment of AVMs. Despite these excellent tools, an enhanced understanding of the biology of AVMs is sure to allow for the development of less invasive, biologic-based therapies for these lesions; already several groups have experimented with the use of beta blockers and statins as anti-inflammatory, anti-angiogenic factors to remedy these challenging vascular malformations.

PAEDIATRIC AVMs SYMPOSIUM**Sidlaw**

Chair: Shelly Renowden

Lecture 25

14.00 - 14.20

Vein of GalenJoti Bhattacharya

Royal Hospital of Sick Children, Glasgow, UK

Management of vein of Galen aneurysmal malformations (VGAMs) remains one of the most challenging areas in modern medicine. These are the most frequent, though still rare, vascular malformation of the brain in neonates and small children. They are characterised by a ballooned venous pouch, commonly believed to represent a dilated median prosencephalic vein (of Markowski) with multiple arteriovenous shunts in its wall. Although as a complex arteriovenous shunt, treatment principles resemble those for common adult brain AVMs, the usually small size of the child, the immaturity of the brain and the fragility of the cerebral vasculature demand very specific management protocols. Operative neurosurgery and stereotactic radiosurgery have little role in the management of these children which has been transformed by the development of interventional neuroradiology. This lecture discusses current multidis-

ciplinary approaches to managing children with VGAM based on our experience with more than 40 children, most seen as part of the UK vein of Galen National Service in Glasgow.

Lecture 26

14.20 - 14.40

Pediatric AVM Phenotypes

Timo Krings

Toronto Western Hospital, Toronto, Canada

Pediatric vascular malformations of the central nervous system differ from those seen in adults. Pial arteriovenous malformation in the pediatric population can be either fistulous or of the nidus type. In fistulous AVMs there is a direct transition of an often significantly enlarged artery into a venous pouch. These fistulous AVMs are typically high flow lesions and typically have a single feeder. In the pediatric population, high flow angiopathic changes surrounding the AVM are rather uncommon. Fistulous AVMs get symptomatic at an early age and may present with hemorrhage, but also, depending on the shunt volume, with cardiac insufficiency or psychomotor retardation. Whenever a fistulous AVM is detected in a child, HHT (hereditary hemorrhagic telangiectasia) has to be ruled out and the potential for multiplicity of these shunts has to be taken into consideration. In contrast to the subpial location of fistulous AVMs, nidus-type AVMs are classically located in the brain parenchyma and are characterized by a network of abnormal vessels in between the feeding artery (or arteries) and draining vein(s). They manifest themselves later and most commonly with hemorrhage, followed by epilepsy and headaches.

Lecture 27

14.40 - 15.00

SRS for Paediatric AVM – Special Considerations for the Developing Brain

Christer Lindquist

BUPA Cromwell Hospital, London, UK

The most common cause of cerebral haemorrhage in children is the rupture of an arteriovenous malformation, which may result in devastating neurological deficits or death. Shunting of cerebral blood flow may cause epilepsy, acute or chronic ischemic neurological deficits

and may directly or indirectly result in retardation of brain development. Radiosurgery has been used as a treatment modality for cerebral AVM in children and adults for 4 decades. The number of publications on the *Results* of radiosurgery for pediatric AVM are few compared to those on treatment of AVM in adults. So far the *Results* published on treatment of children with radiosurgery are as good as those published on the treatment of adults. Nevertheless, there are several reasons for giving special attention to the use of radiosurgery for AVM treatment in children. The risk of developing malignant tumours later in life is one of them. Another is the risk of retarding brain development by effects on cerebral stem cells and/or gray and white matter. The radiation and patient parameters known for affecting outcome will be summarized from a radiobiological perspective. A review of recent *Results* and complications of radiosurgery for cerebral AVMs in children will be presented and an attempt made to give guidelines for patient selection and complication avoidance.

Lecture 28

15.00 - 15.20

Surgical Considerations for Paediatric AVMs

Juha Herniesniemi

Helsinki University Central Hospital, Helsinki, Finland

During 1937 - 2005 631 patients with AVM were admitted to the Department of Neurosurgery in Helsinki University Hospital². Out of 631 patients, 101 were aged under 18 on admission. Patients underwent microsurgical removal of their AVM. Preoperative embolization was used in 39%. Median interval between hemorrhage and operation in ruptured cases were 8 days. AVM was completely occluded in the postoperative DSA in all cases. Significant postoperative complications included major vessel occlusion, hydrocephalus and meningitis, all in one case each. Outcome three months after discharge was assessed on Glasgow Outcome Scale. Three fourths (77%) made a good recovery, 15% had moderate disability, 4% patient had severe disability and 4% died. Pediatric patients with AVMs present with hemorrhage more often than adults, and their AVM seems to be more often located in a challenging region, such as posterior fossa or deep regions.

The treatment policy in this population should favor aggressive treatment aimed at the complete eradication of the AVM, if possible, since the life expectancy after successful treatment is decades and the potential for neurological recovery very high. In the unselected, population-based series of senior author's pediatric AVM patients, outcome was favorable in 92% of cases despite the high proportion of cases presenting with severe hemorrhages and complex AVMs ¹.

References

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- 2 Hernesniemi JA, Dashti R, Juvela S, et al. Natural history of brain arteriovenous malformations: a long-term follow-up study of risk of hemorrhage in 238 patients. *Neurosurgery*. 2008; 63: 823-829; discussion 829-831.

WHAT HAVE WE LEARNT FROM OUR COLLEAGUES?

Chair: Rustam Al-Shahi Salman

Lecture 29

16.20 - 16.40

How Do I Want My AVM Managed Now? The Unbiased View?

Rustam Al-Shahi Salman¹, Christian Stampf²

¹ Western General Hospital, Edinburgh, UK;

² Hôpital Lariboisière, Paris, France

No abstract available.

Lecture 30

16.40 - 17.00

Neurosurgery

Robert Spetzler

Barrow Neurological Institute, Phoenix, USA

The importance of multi-disciplinary approach is nowhere more apparent than in the treatment of arteriovenous malformations (AVMs). As neurosurgeons we have learned a great deal about AVMs from our colleagues in the basic sciences, interventional neuro-radiology and radiosurgery. The basic sciences have begun to shed light on the mechanisms involved in the branching of the vascular tree. Using model organisms, they have educated us on the role of important signaling cascades such as vascular endothelial growth factor (VEGF), Ephrins, and members of transforming growth factor-beta (TGF- β) family

on arteriovenous development. Enhanced understanding of these processes is sure to lead to discovery of new therapies for these lesions. Endovascular technique is constantly evolving and pushing the frontiers on treatment. With the introduction of new embolysates such as Onyx, endovascular practitioners have begun to aggressively obliterate arterial feeders to AVMs with significant reduction in morbidity. Our endovascular colleagues have also shed light on the importance of hemodynamic factors and alterations of blood flow associated with treatment of AVMs. Their contributions have resulted in decreased blood loss, decrease in operative times and improved outcome of patients. With improvements in radiosurgical technique, stereotactic radiosurgery has become an important adjunct for the treatment of AVMs. Radiosurgeons have thought us important lessons about the response of AVMs to radiation, the long-term effects of radiation on not only the lesion, but on the patient as a whole, and mechanisms of AVM obliteration by radiation. As a discipline, Neurosurgery has benefited greatly from symbiosis with colleagues in the basic science, endovascular and radiosurgery. A continued team approach is sure to not only improve our understanding of these lesions, but also to lead to more efficacious and less morbid therapies.

Lecture 31

17.00 - 17.20

INR

Georges Rodesch

Hôpital Foch, Suresnes, France

No abstract available.

Lecture 32

17.20 - 17.40

SRS for Thalamic, Basal Ganglia and Brainstem AVMs

Andras Kenemy

Royal Hallamshire Hospital, Sheffield, UK

The major determinants of radiosurgical outcome of deep eloquent AVMs are size and location. Radiosurgery for such AVMs smaller than 4 cm³ is safe and effective in all anatomic subgroups. Obliteration rate is significantly lower in midbrain and peritectal diencephalon,

but morbidity is mild and low, and repeat radiosurgery is effective. Brainstem lesions larger than 4 cm³ have poor outcome; therefore, radiosurgery alone is seldom recommended. Only half of the thalamic/basal ganglia AVMs larger than 4 cm³ are cured with excellent to good outcome with single-stage radiosurgical treatment, but a second radiosurgical session is curable in another two-thirds of the patients with low additional risk. Overall, posttreatment morbidity and mortality of these large thalamic/basal ganglia lesions are significantly higher than small and/or less eloquent AVMs, but their natural history is dismal. It is hoped that the recently introduced staged volume radiosurgery may improve outcome in this group.

Lecture 33

17.40 - 17.50

Future Research

1) MARS the Multicentre AVM Research Study

J.P. Mohr

University of South Alabama

A database for brain AVMs was assembled through the guiding efforts of Helen Kim, UCSF, from the files of UCSF Brain AVM Study Project (n=736), Columbia AVM Study (COL, n=672), Kaiser Permanente of Northern California AVM Study (KPNC, n=856), and Scottish Intracranial Vascular Malformation Study (SIVMS, n=218). The effort was to estimate the occurrence of BAVM treatment, death, last visit, or 10 years of follow-up, analysed by Cox proportional hazards time-to-haemorrhage after diagnosis. The overall annual hemorrhage rate of 2.3% for the whole cohort showed higher rate when the bAVM had bled at presentation (4.4%, 95% CI x to y) compared when they had not. Hemorrhagic presentation (HR=3.3, P<0.001), exclusively deep venous drainage (HR=2.0, P=0.001), and associated arterial aneurysms (HR=1.8, P=0.013) were significant univariate predictors of haemorrhage during follow-up and haemorrhage at presentation (HR=3.7, P<0.001) and increasing? Age at diagnosis (HR=1.3, P<0.004) were independent predictors. inclusion of more cohorts could only improve the precision of these estimates and help develop clinically useful risk prediction models.

Lecture 34

18.00 - 18.10

Future Research

2) Minocycline for Patients Unsuitable for Invasive Therapy

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Arteriovenous malformations of the central nervous system are evolutionary dynamic diseases. Time has thus to be considered when analysing such a lesion: brain AVMs may be absent and develop, or exist and regress. The congenital nature of these lesions has therefore been even questioned. This dynamic aspect is related to angiogenesis and vascular remodelling. Angiogenesis belongs to the daily life of brain AVMs, and includes either non sprouting or sprouting phenomena. Non sprouting angiogenesis is the creation of a new vascular wall without creation of a new vascular lumen.

Angioectasia and leptomeningeal supply belong to that category. Sprouting angiogenesis consists in the budding of new vessels from pre-existing ones: angiogenesis due to clot resorption, or creating dural attachments, is related to that category. Ischemia may induce a mixed type of angiogenesis (sprouting and non sprouting).

The angiogenic phenomena seen in brain AVMs are thus morphological answers to biological triggers or anomalies. They will contribute to constitute the angioarchitecture of the lesions, and may participate to build up their natural history. The brain being an archeological organ constituted by a paleo, archi and neopallium, and the neopallium being made of several histogenetic subunits, each of them being under the influence of specific genes, transmitters and biological factors, angiogenesis may potentially be a tailored answer of an AVM to a trigger that is specific to the location of the shunt in a given patient. Emphasized more than 30 years ago by Lasjaunias and Berenstein, updated recently by Valavanis, the concept of "host" for a brain AVM in such a patient could be influenced by the histogenetic unit in which it is embedded. Improvements in the understanding of brain AVM will therefore have to leave the current technical and morphological grounds for a proper insight into the biology of the vessel.